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The Effect of Language Immersion on Second Language Intonation

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This study investigated the effect of language immersion in an English-speaking environment on the production of intonational features in L2 English sentences. It was hypothesized that the Korean group who had been immersed in the English language as children would have intonation patterns more similar to native English speakers than a non-immersed group of Korean speakers, who shared otherwise similar experience and proficiency with English. Sixty subjects in three groups – 20 Korean adults in the immersed group, 20 Korean adults in the non-immersed group, and 20 native English speakers (as a control group) – took part in the experiment. The immersed group was more native-like by having a steeper F0 declination tilt (a wider F0 range and a fast speech rate). However, the immersed group, like non-immersed group, exhibited difficulty in resetting F0 between adjacent phrases at boundary. These results suggest that the acquisition of second language (L2) intonation is affected by early immersion in an L2 environment, but the degree of intonational acquisition was shown to vary by subareas, in which some F0-related cues proved to be hard to acquire.

Key Words: second language acquisition, immersion, intonation, F0, speech rate, declination tilt, boundary cues

1 Introduction

Intonation plays a crucial role in intelligibility. Intonation refers to the use of suprasegmental phonetic features to convey sentence-level pragmatic meanings in a linguistically structured way (Ladd, 1996). These structures are affected by characteristics of the speech as well as by subject variables. The aim of the study is to investigate how the effect of early immersion has influence on acquiring L2 intonation. For this investigation, intonational phonetic features such as overall F0 declination tilt and extent of boundary resetting were analyzed.

Intonation is considered an important aspect of prosody affecting intelligibility in L2 speech production (e.g., Laures & Weismer, 1999; Maassen & Povel, 1985; Mennen, 2006). Even though intelligibility is related to both segmental (Jenkins, 2000; Munro & Derwing, 2008) and prosodic features (Anderson-Hsieh & Koehler, 1988; Tajima, Port, & Dalby, 1997),

some researchers have reported that prosodic factors are more important than segmental factors for perceived foreign accent and intelligibility (e.g., Anderson-Hsieh & Johnson, 1992; Bradlow, Torretta, & Pisoni, 1996; James, 1976; Tajima, Port, & Dalby, 1994). Since intonational features provide information for the interpretation of elements in a sentence as new versus old, salient versus weak, or foreground versus background, its function is crucial in acquiring the intelligible prosody of the second language (e.g., Morley, 1992; Wennerstrom, 1991, 1994).

L2 Intonational features are affected by various factors: the age of L2 acquisition (Guion, et al., 2000; Tahta, et al., 1981), language experience (Flege & Liu, 2001; Mennen, 2004; Trofimovich & Baker, 2006), the background of the native language (Archibald, 1995; Archibald, 1998; Davis & Kelly, 1997; Guion, et al., 2004), and motivation (Conrad, 1991; Moyer, 1999). Among these factors, transfer from the native language has been suggested to play a key role in forming L2 intonational production. Delattre (1963) claimed that speakers tended to impose their native intonation patterns on their second language. In his study, a French learner of English produced different intonation from an English native due to the use of French intonation patterns in the English production. Wennerstrom (1994) investigated the English prosody produced by native Spanish, Japanese, and Thai speakers and reported that while the native speakers made significant use of pitch contrasts to signal focus on the items measured, the non-native speakers did not consistently use pitch to signal meaning contrasts in many of the same environments. Aoyama and Guion (2007) reported that there were considerable differences between English spoken by L2 Japanese speakers and native English speakers, both in duration of linguistic units and overall F0 range and suggested that the prosodic differences stemmed from L1 background. These studies draw the conclusion that the effect of immersion experience decreases the degree of the L1 transfer for early children as well as adult learners.

To date, how the experience of early immersion has influences on L2 intonational acquisition was rarely researched, comparing non-immersed groups with almost equal L2 proficiency. Some longitudinal studies, however, report contradictive results (e.g., Trofimovich and Baker, 2006). Grover et al. (1987) reported that 10-year-old French immersion subjects produced the French intonation more natively than 16-years old students. Also Shen (1990) reported that some Chinese learners of French with 7 to 14 years were judged to produce French interrogative intonation with significant accuracy. On the contrary, other studies suggest opposite results for the effect of early immersion. Lepetit (1987) found that Japanese learners of French with different ages and learning experience did not exert meaningful intonation contours.

This variability of the results in L2 learners' acquisition of intonation might be attributed to methodological problems. Most previous studies of L2

intonation acquisition investigated the age effect for longitudinal variation (see Trofimovich and Baker, 2006). These studies assume the background hypothesis that L2 suprasegmental factors could be developed naturally over time and experience in an L2 settings (e.g., Guion et al, 2001). However, some papers reports that L2 acquisition of suprasegmentals by immersion effect could be different depending on the environment of ESL or EFL (Aoyama, Guion, Flege, Tsuneo, Akahane-Yamada, 2008; Kang, Guion, Rhee, and Ahn 2011). Kang, Guion, Rhee, and Ahn (2011) reported that different developmental directions of L2 suprasegmentals could be found for Korean learners of English, examming both groups of immersed and non-immersed L2 learners. What specific intonational factors are influenced by the immersion, however, still remains unsolved.

Intonation can be viewed in two ways: phonetics and phonology. Phonetic approach is the acoustic correlate of pitch represented as F0 contours which are plots of F0 against time, while phonological representations are used to describe discrete expression of pitch contours. In the present study, we take up intonation in its phonetic levels, and thus focus on size of declination slope in whole sentences as well as the resetting of slope at boundary, since F0 declination has been claimed to be very much L1 dependent (e.g., Thosen, 1984) as well as speaking style-dependent (e.g., Umeda, 1982). In its formation, declination is greatly affected by a reset which exerts coincidence with boundary cues of various linguistic units.

The aim of the study investigates the influence of immersion during childhood on the acquisition of L2 intonation. The goal of the study is to extend our understanding of factors influencing the acquisition of intonation, which importantly affects intelligibility of L2 speech production. As the immersed group received massive exposure to spoken English as children, we predicted that their intonation patterns would be more native-like than the non-immersed group who acquired English for a similar period of time and had similar proficiency on standardized English tests.

2 L1 Intonational Structure

As a universal linguistic feature, there is a general tendency for F0 to begin on a moderate frequency, move to a higher frequency, and then lower across the sentence (Pike, 1945). The intonation of most languages can be characterized by the declination theory, in which the declining F0 that gradually falls throughout the course of a sentence represents a linguistically salient aspect of the F0 contour. Declination is found in English (Liberman et al., 1985; Maeda, 1976; Pierrehumbert, 1980), Dutch (Cohen, Collier, and t'Hart, 1982; Strik and Boves, 1995; Thorsen, 1985; van Heuven, Vincent, & Haan, 2000), French (Beyssade & Marandin, 2006; Hirst & Cristo, 1998), Japanese (Fujisaki & Sudo, 1971; Pierrehumbert & Beckman, 1988), and Finnish (Välimaa-Blum, 1993).

The degree and type of the F0 movement, however, may vary by languages and linguistic structures which are affected by the type of intonational structures they possess. Korean has a different intonational structure from English. Korean has two prosodic units above the prosodic word: the intonational phrase (IP) and the accentual phrase (AP) (Jun, 1998; Jun, 2005). An IP is defined by phrase final lengthening as the form of a boundary tone and also is the highest prosodic unit defined by intonation, including one or more APs. An IP boundary tone has a falling F0 pattern in declarative sentences. APs in Korean do not have any pitch accents associated with stressed syllables in their domain and also lack the phrase accent which occurs at the end of the intermediate phrase of English. APs are associated with tonal patterns; the basic type being LHLH, though 15 tonal patterns have been described, based on the number of syllables and segmental make-up of the AP[1]. In Korean, however, it is difficult to find the distinctive declination tilt because the narrow pitch in an IP-final part is not applied. Since there is only one accented syllable usually in the IP-final syllable, this makes it hard to form a top-line.

English, unlike Korean, is a stress language in which one syllable is stressed within the prosodic foot. The stressed syllable tends to have a greater duration, higher pitch, and more complicated contour of F0 than the unstressed syllables and serves as the syllable on which pitch accents are realized. English has three prosodic units above the prosodic foot: the intonation phrase (IP), the intermediate phrase (iP), and accentual group (AG) (Wells et al., 2004). An IP is the highest prosodic unit defined by intonation and may contain one or more iPs. It has final lengthening with the final falling F0 in the case of declarative sentences. An iP has to contain at least one pitch accent with either falling or rising F0. Each iP consists of one or more AGs, defined as the domain for a pitch accent configuration. Also AGs contain one or more Feet, each of which comprises a strong initial syllable and following weak syllables.

The L1 intonational structure has some influences on L2 intelligible speaking. Jilka (2000) reported that German/American bilinguals used a wider range of pitch in their American English than in German. The F0 declination patterns are also affected by phrase types. The English IP has a falling F0 contour as a terminal or final signal, while the iP, as a non-terminal or continuity signal, has various patterns of F0 contour: LHL, HLL, HL, LL, LLH, H, L, etc. Lieberman (1967) suggested that variation could be found in the non-terminal part of the fundamental frequency contour, in that the lower unit of the iP might have various F0 contours different from higher units of the IP. This implies that such difference is due to the intonational differences in terminal or non-terminal sentences.

[1] Jun (2000) reports the 15 types of phrasal tones in Korean: LH, LHH, HLH, HH, HL, LHL, HHL, HLL, LL, HHLH, LHLH, LLH, HHLH.

The study of intonation involves the analysis of internal structure and shape of intonational contour. In this study, the internal structure of intonational phrases in L2 English will be investigated. The aim of the study presented here is to determine how and to what extent Korean learners of English produce native-like intonational patterns and the effect of immersion on that production involves in shaping L2 intonation. In this pursuit, we examine the upper-lines and lower-lines of the F0 contour as an estimate of F0 declination as well as duration and mean F0 at the boundary and F0 difference and duration between two phrases as a reset of the intonation.

3 Methodology

3.1 Participants

The data were collected from 60 adult participants. None reported being diagnosed with a language or speech disorder. The participants were divided into three groups of 20 each: IS (Immersed Speakers) of male Koreans learning English; NIS (Non-Immersed Speakers) of male Koreans learning English; and NE (Native English Speakers) (20 males). The characteristics of participants in the three groups are presented in Table 1. Most of the NE participants were students of the University of Oregon. They did not speak any language other than American English on a daily basis when they took part in the experiment. The IS subjects were selected based on early immersion experience in an English-speaking country. The ISs had learned English in the U.S. or Canada during elementary or secondary school (ranging from 3 to 6 years of immersion duration), after which time they returned to live in Korea[2]. At the time of the experiment, they were all university students in Korea who were majoring in English, or international studies and related fields at a private university in Seoul. Korean NISs were students majoring in the same disciplines at the same university as Korean ISs. The students in both groups had begun learning English in their home country, South Korea, starting from 3rd grade of the public elementary schools. Most of them studied English for six hours a week in both schools and private institutions in which native Korean speakers served as English teachers.[3]

[2] At the time of the experiment, some top-ranked universities in Korea where some subjects attended had a special entrance permit for applicants who had re sided for several years abroad. This implies that the academic abilities may not be equal between the two Korean groups because some IS members didn't tak e the same university entrance exams as the NIS group.

[3] Three subjects of NIS had experience learning English from native English speakers in private institutions during secondary education. At the time of experiment, half of NIS members attended English classes instructed by English native speakers at their universities

As we wished to study the effect of immersion on intonation in L2 speech production, we sought to control the level of English proficiency between the two groups. In that way, differences in production could be more likely attributed to an effect of immersion than overall English proficiency. We used universal standardized tests to select subjects who had similar English academic proficiency between the two Korean groups. ITP TOEFL consisted of a reading comprehension, structure and written comprehension, and reading comprehension, and the maximum possible score was 677 at the time of experiment. This test was chosen because it was designed to test English proficiency as an academic basis and it is also known to be a reliable tool to measure English proficiency. The test was administered to all participants in the two Korean groups. The immersed group performed at 79% accuracy (534/677), with a mean of 518.17 and a standard deviation of 23.91 in the reading section, a mean of 562.16 and a standard deviation of 43.37 in the listening section, and a mean of 527.92 and a standard deviation of 35.2 in the structure and written expression. Then we identified similar NISs from a larger sample. The 20 NISs who performed similarly to the ISs were selected. These NISs performed at 77% accuracy (521/677), with a mean of 538.33 and a standard deviation of 28.55 in the reading section, a mean of 516.58 and a standard deviation of 31.87 in the listening section, and a mean of 527.92 and a standard deviation of 35.2 in the structure and written expression. An independent t-test for the two Korean groups, performed on the proficiency score test, revealed little difference between the two groups ($t = .818$, $df = 39$, $p > .05$). There was no significant difference between the two Korean groups with regard to English level. Table 1 presents participants' information including age, the number of years they had studied English, and the number of years they spent in America.

Table 1. Subjects' Information

Group	Age	LOR	LOE	ITP-TOEFL®	Number
NE	21.3	-	-	-	20m
IS	21.1	4.7	10.3	534	20m
NIS	23.2	-	10.2	521	20m

LOR: length of residence in North America (year); LOE: length of learning English (year); ITP TOEFL: Institutional testing program TOEFL; m: male

3.2 Materials and procedures

All participants were recorded individually in a quiet room using a portable digital recorder. All 60 subjects heard the same recorded stimuli in the same order and were recorded using the same equipment. The elicitation procedure allowed for the collection of fluently produced sentences without the need for reading, while also minimizing the likelihood of mimicry. 15 declarative

sentences and 1 paragraph were used (see Appendix).

The presented English written lists shown in Appendix were presented to the subjects as a separated methods. For 15 sentences, they were encouraged to be modeled aurally in short dialogues using prerecorded stimuli. For example, the test sentence "I closed the door and waited for the bus" was elicited using these materials:

PC monitor: What did you do? (pause)
PC monitor: I closed the door and waited for the bus. (pause)
Interviewer: What did you do? (longer pause)

After hearing a question and a response through computer monitor, followed by the same question a second time, the subjects were asked to repeat the model sentence (i.e., what was said by interviewer). The delay between the model and its repetition as well as the intervening speech material were expected to prepare for the speaking. For 1 paragraph which includes longer sentences, the whole contents of the story were presented on the monitor and subjects were encouraged to read the story. The reading of the paragraph was used only in analyzing the reset cues between intonational phrases. Before they produced the sentences, it was confirmed that they knew what the sentences meant, and that they knew how to pronounce them. Also, Korean subjects were given 30 minutes to practice the sentences before the experiment. The sounds were recorded with a Marantz PMD 650 using a Shure SM 10A microphone, digitalized at 44.05 kHz and 16 bit resolution.

3.3 Intonational measurements

English sentences were used to evaluate the prosody of each group. Several acoustic measurements of fundamental frequency (in Hertz) and duration (in milliseconds) were made. Duration and fundamental frequency were measured using a waveform display with a time-locked wideband spectrogram with the software PRAAT (5.1.17). All acoustic cues were measured from the initial acoustic signal in both the waveform and the spectrogram to the final acoustic cues of the boundary such as burst or spectral cues (Kent and Read, 2003; Ladefoged, 2001). Measures for F0 declination tilt were made in 15 sentences. For the presented paragraph, the measures of pause duration and F0 difference between adjacent phrases for F0 resetting were made.

For 15 sentences, the F0 was measured at the onset of the phrase, the absolute maximum point of the F0 peak, the absolute minimum point of the F0 valley, the local maximum point of the final F0 peak, the local minimum point of the final F0 valley, and the F0 at phrase offset. Thus, F0s and times in six points of a sentence were collected and calculated to form slope line, in which F0 range forms x-axes and time duration (otherwise speech rate)

shapes y-axes. The declination tilt γ was computed as follows.

$$\gamma = \frac{\triangle f}{\triangle t}$$

where Δf is the range difference of f0 declination over durational time.

Based on the formula, the intonation contours for the upper-line and lower-line were determined in mixed fashions of those in Cohen et al. (1982), Thosen (1984), and Fujisaki and Sudo (1971). In this study, the adopted method provides information to compare the size of F0 slope and duration across the three groups[4]. The upper-line connects the first maximum peak of F0 appearing in the initial part of the sentence to the final peak F0 of the utterance, while the lower-line connects the initial minimum point of F0 to the final valley point of F0 in the sentences. The formulas were as follows:

Upper - line

$$= \frac{\text{the initial peak of F0 - the boundary peak of F0}}{\text{duration} * 100}$$

Lower - line

$$= \frac{\text{the initial valley of F0 - the boundary valley of F0}}{\text{duration} * 100}$$

If the slope approximates 0, a level intonation between the two measured points of F0 is indicated. If the slope has a negative value approaching -1, it means that the initial peak point of F0 is higher than the final peak point of F0. On the contrary, in the case of a positive value approaching +1, it means that the final peak point of F0 is higher than the initial peak point of F0 (Positive values usually appear in the interrogative sentences.). Several features were measured:

[4] Lieberman et al. (1985) points out some subjectivity resulting from eye-fitting procedures, criticizing the Maeda (1976). However, this study adopts the methods of Cohen et al. (1982) and Thosen (1984) because they give us good information about intonation-related parameters for group comparisons.

Y-axe features
- F0 values at onset and offset positions
- The minimum and maximum values of F0
- F0 range at the first peak, midpeak, and final peak.

X-axe features
- The durational times to the minimum and maximum values of F0
- The durational times between onset and offset position

Boundary tone features
- The duration at boundary foot
- Mean F0 at boundary foot

Reset features
- F0 difference between phrases

Y-features: The declination tilt was measured using two cues: F0 range as a Y-axe, and speech rate as an X-axe. The F0 range, one of a Y-features, is known to be an indicator of English proficiency (e.g., Backman, 1979; Willems, 1982). Generally, a lower proficiency with English as a second language is related to a narrower F0 range. In this study, the range was measured from the highest point to the lowest point of the fundamental frequency in three areas: overall range of F0 across the phrase; F0 range in the maximum point of F0 mostly occurred in the initial part of the phrase; and F0 range at the final stressed syllable in the final foot of the phrase. We used the F0 tracing generated by Praat to determine peaks and troughs. F0 was also calculated from the duration measurements of individual cycles in the waveform as a supplementary check on the accuracy of the F0 tracker.

X-feature: As an X-axe, speech rate has proved to be a good indicator of the second language proficiency (e.g., Derwing & Munro, 1997; Guion et al., 2000). In this study, the speech rate is operationalized as duration measured from the initial acoustic signal of the phrase in both the waveform and the spectrograms to the final acoustic or spectral cues of the phrase boundary.

Boundary features: Final strengthening at boundary is realized in prosodic domains (e.g., mora, syllable, foot, or prosodic word) at the end of the phrase in the form of longer duration (Beckman & Edwards, 1991; de Pijper & Sanderman, 1994; Wightman et al., 1992), strengthening (Fourgeron & Keating, 1997), and alternation of the degree of overlap with adjacent segments (Byrd & Saltzman, 1998). This study measured the duration and mean F0 in the phrase-final syllable because the final lengthening and final strengthening as a form of local peak F0 or lengthening as a form of longer duration occurs in this part. For example, “day” in “My brother is coming on

Friday" was measured.

Reset feature: Reset at boundary elements are analyzed. In the sentences containing two intermediate phrases, the conjunction between the first non-terminal and the second terminal phrase was also assessed. The pause duration between the two phrases was measured. Additionally, the F0 at the final point of the preceding phrase was compared to the F0 at the initial point of the following phrase.

These measures were analyzed with Repeated Measures of Analyses of Variance (RM ANOVAs) which were conducted for statistical evaluation of the groups with the following parameters: Dependent variables of fundamental frequency, speech rate (duration), boundary cues, and the declination tilt measures were examined by the factor of Group (three levels: NE, IS, NIS). The repeated measure of phrases was used in order to consider the individual variation (each sentence by each speaker) along with within group variation (F0 range and speech rate for declination tilt along with F0 difference and pause duration for a reset). Repeated measures were used in order to account for within speaker variance in pronunciation. A repeated-measures design is able to factor out some of the variation that occurs within individuals.

4 Data Analysis

Three analyses were performed. The first analysis examined the extent to which the learners were able to produce L2 intonation intelligibly, as measured by overall intelligible ratings. In this analysis, the sentences spoken by the subjects were presented to twenty native English raters for evaluation. Then, the judgments were compared across both groups of L2 Korean learners and the native English speaker group.

The second analysis examined the extent to which the learners were able to accurately produce specific intonations. The results of the acoustic measurements obtained were compared. The purpose of the experiment was to analyze to what extent each measurement has been affected over both L1 and immersion. The final analysis extended the findings of the first two by using a multiple regression procedure to investigate how the learners' production of specific intonational features contributed to native listeners' intelligible judgments in the L2 speech.

4.1 Ratings of intelligibility

4.1.1 Ratings and raters

Samples from paragraph recordings ensured that the content was held

relatively constant across speakers. The forty samples (twenty for 20 IS speakers and twenty for 20 NIS speakers) were randomized and presented to the native English raters using a loud speaker. The total of twenty native-speaking English listeners (twelve males and eight females; age range 20-26 years, M=23) were recruited to evaluate the intelligibility of the L2 speakers using a 9-point Likert scales (from 1 = no intelligible speaking to 9 = extremely native-like intelligible speaking). The experimental sentences were presented to a group of ten native speakers of English for intelligible judgment. All of the raters were native English speakers who had some experience in teaching English in Korea. All raters reported normal hearing.

For the judgment, the raters listened to some of the paragraph samples before rating each speaker. The adaptation of 9-point Lickert scale follows the study of Southwood & Flege (1999) that a 9 or 11-point scale is the most appropriate rating scale to evaluate L2 speech samples for the degree of intelligible speech. The raters were encouraged to use the entire scale and to guess if they were unsure. After confirming their pre-rating tests, they started rating the speech separately.

5 Results

The first purpose of the present study was to test the hypothesis that immersed learners were more likely to produce intelligible L2 intonation. The ratings of the samples indicated that most of raters kept the reliable results. The dependent variable in this analysis was the mean of intelligible ratings calculated by averaging the twenty English listeners' ratings on the forty Korean subjects. The intra-class correlation coefficient was used to measure the degree of inter-rater reliability for each group of raters' evaluation of the subjects' speaking. The raters' coefficient was highly correlated, $r(20) = 0.96$, $p < .0001$. These results indicated the high levels of agreements among all the native raters.

Figure 1 presents the mean scores of fluency ratings obtained for both groups of Korean. The scores for both Korean groups are quite different, ranging from 3.0 to 6.0 out of 9. There was a difference in the effects of immersion. In Figure 1, higher mean ratings were obtained for the immersed Korean bilinguals. The difference on the intelligible ratings was significant (immersed group = 5.69, non-immersed group 4.12, $p < .0001$).

The obtained ratings were submitted to an independent t-test with both Korean groups. This analysis revealed a significant group difference ($t = 24.236$, $df = 39$. $P < .0001$). The analysis indicates that immersion experience in childhood has significant influences on determining the patterns of L2 intelligible speech as a native-like manner.

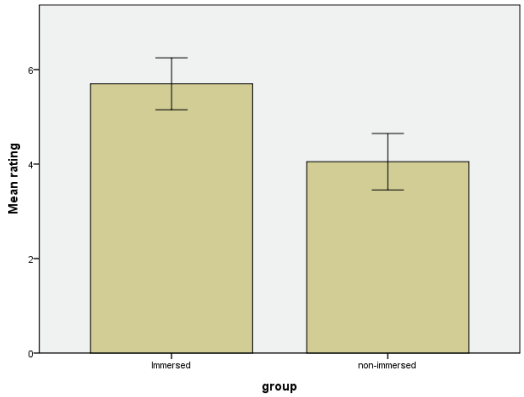


Figure 1. Group means for intelligible ratings (±1 SE) for both Korean groups

5.1 Production experiment

The English phrases were analyzed to investigate differences among the three groups. Table 2 presents the mean values and standard deviation of the F0 range (overall, initial, and final), speech rate, mean F0 and duration of the final foot and slope patterns of upper- and lower-lines. As seen in Table (2) and Figure (3), there were group differences for F0 range, speech rate, and mean F0 and duration of the phrase-final foot.

Table 2. Mean and Standard Deviation of Parameters in the Intonational Phrase

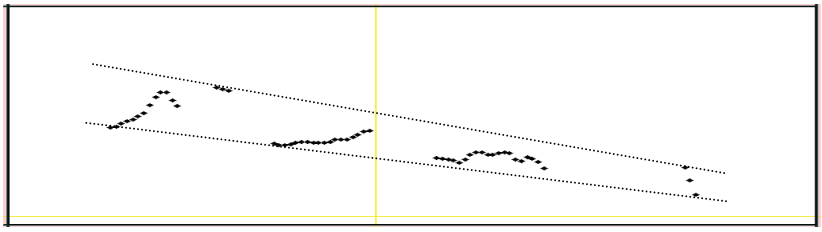
Measure		NE	IS	NIS
Slope pattern	Upper-line	-0.72 (1.08)	-0.59 (0.43)	-0.36 (0.34)
	Lower-line	-0.38 (0.34)	-0.31 (0.28)	-0.22 (0.21)
F0 range (Hz)	Overall Range	120 (55)	116 (42)	94 (43)
	Initial range	60 (32)	56 (42)	47 (37)
	Final range	31 (31)	35 (40)	37 (33)
Speech rate (S)		1.71 (0.3)	2.00 (0.28)	2.41 (0.45)
Phrase-final foot	Mean F0 (Hz)	115 (35)	135 (31)	149 (40)
	Duration (S)	0.25 (0.10)	0.27 (0.11)	0.29 (0.11)
Reset cues	F0 dif. (Hz)	15.45 (28)	4.09 (17)	3.66 (21)
	Pause duration(S)	0.15 (0.14)	0.17 (0.14)	0.36 (0.26)

5.2 Declination tilt

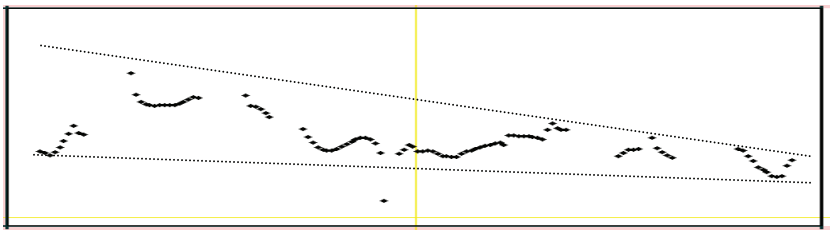
For the intonational slope, the correlation between upper-line and lower-line was significant for the three subject groups pooled, $r = 0.317$ ($p < .01$). This

tilt implied that the two lines were closely related. However, as can be seen in Figure 4, the groups diverged most in terms of the upper-line; the NE group had the steepest slope, followed by the IS and then the NIS groups.

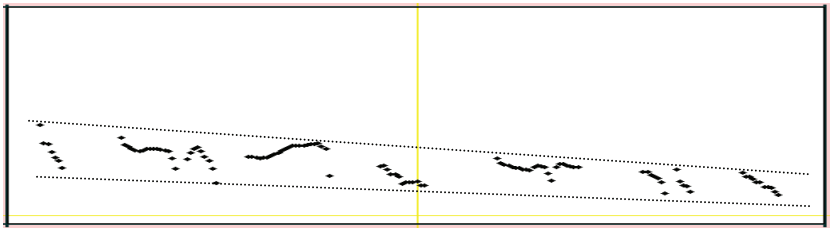
The RM ANOVA confirmed that there was a significant effect of group for upper-lines, $F(2,769) = 26.417$, $p < .001$. Tukey's tests ($p < .05$) revealed that the mean value for the slope of the upper-lines was the steepest for the NE group, intermediate for IS, and the least steep for the NIS group. Results of the RM analysis of variance returned significant effects for the lower-lines as well, $F(2,769) = 23.711$, $p < .001$. Tukey's tests ($p < .05$) revealed that the mean value for the slope of the lower-lines is steeper for the NE group, intermediate for IS, and the least steep for the NIS group. The results are summarized in Figures 2, in which the F0 contour presented here is the sentence of "I closed door and waited for the bus".



(a) Native speaker



(b) Immersed English speaker



(c) Non-immersed English speaker

Figure 2. F0 declination tilt of three groups

In Figure 2, NE group shows comparatively steep slopes of the upper-line and lower-line (-0.72 and -0.38), wider F0 range of 120 HZ for the entire sentence, 60 Hz in the initial part and 31 Hz in the final foot, and sentence duration of 1.71 seconds. The IS group is between NE and NIS group. They show slopes of the upper-line and lower-line (-0.59 and -0.31), mean F0 range of 116 Hz in the entire sentence, 56 Hz in the initial part and 35 Hz in the final foot, and sentence duration of 2.00 seconds. Finally NIS group shows gentle slopes of the upper-line and lower-line (-0.36 and -0.22), narrower F0 range of 94 Hz in the entire sentence, 47 Hz in the initial part and 37 Hz in the final foot, and sentence duration of 2.41 seconds.

F0 range

For the F0 range as an x-axe, the RM analysis of variance confirmed that there was a significant effect of group on Overall F0 range, $F(2,899) = 21.967$, $p < .001$. Tukey's tests ($p < .05$) revealed that the F0 range was smaller for the NIS group than the NE and IS groups. Figure 3 (a) presents the F0 range produced by the three groups. The results showed that members of the IS group produced differences in the F0 range similar to the native speakers. However, members of the NIS group showed a comparatively smaller range in F0. This result supports the proposal that more fluent learners of English as a second language have a wider F0 range when speaking English than less fluent learners (e.g., Bradlow et al., 1996; Mennen, 2006).

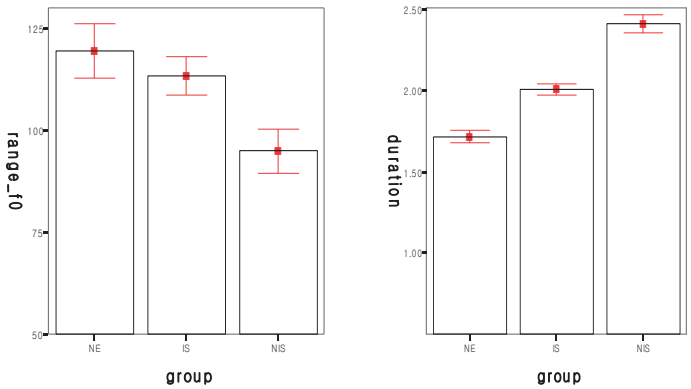
A narrower F0 range could be evidence of the influence of the native language (Scherer, 2000; Van Benzooijen, 1995), or reflect a lack of proficiency in the second language (Backman, 1979; Willems, 1982). It is unclear whether the narrower F0 range of the NIS group results from the influence of Korean or from NISs' uncertainty about English pronunciation. However, it is noteworthy that the F0 range of Koreans is only 70% of the English F0 range, which has more F0 variation. The F0 range for the IS group closely approximated the range the NE group, perhaps showing less L1 interference than the NIS group.

An interesting observation about the F0 range is that, although all groups have a wider range in the initial part of the sentence and a narrower range in the final syllable of the sentence, the degree is different. NEs' initial range is almost two times larger than the final word, but the NISs' range is almost level between the two measured areas for F0 range, which produces a relatively more monotonous intonation. ISs follow the patterns of NEs: wider range of the F0 in the initial part and narrower range of the F0 in the final part.

Speech rate

For the speech rate as a y-axe, the results of the RM analysis of variance confirmed a significant effect of group on speech rate, $F(2,899) = 358.964$, $p < .001$. Tukey's tests ($p < .05$) revealed that the phrase duration was shorter for the NE group, intermediate for IS, and longer for NIS. Figure 3 (b) presents the mean value of duration for the three groups. These results agree with previous work in which more native-like speech was produced with a faster speech rate (Adams & Munro, 1978; Guion et al., 2000; Lennon, 1990; Munro & Derwing, 1995; Sluijter & Van Heuven, 1996). The results showed that the immersed group produced sentences with intermediate durations between the NIS and NE groups, indicating that immersion has an influence on speech rate.

The reason why NISs produce the slow sentence duration stems from failure to control various components of an utterance, including content versus function words, stressed versus unstressed syllables, and movement durations versus steady-state durations. They tend to produce function words and unstressed syllables with higher pitch and longer duration than the NE group. However, the immersed group approached the patterns of NE group, distinguishing stress/unstressed syllables, strengthening content words, and lengthening the pitch contour on focused words.



(a) F0 range (Hz) (b) Speech rate (S)

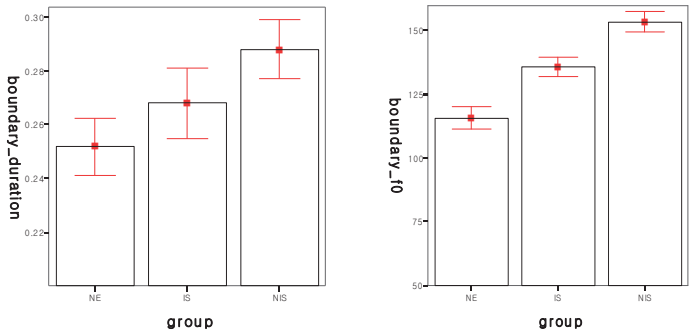
Figure 3. Mean values with standard errors for two acoustic parameters [(a) overall F0 range; (b) Speech rate] by three groups of twenty speakers each (NE, IS, NIS)

Mean F0 and duration of Phrase-final foot

Both mean F0 and duration of the phrase-final foot were measured. The RM analysis of variance revealed that there was a significant effect of group on the duration of the phrase-final word, $F(2,899) = 32.984$, $p < .001$. Tukey's tests ($p < .05$) revealed that the duration was longer for the NIS group than the IS and NE groups. See Figure 4. It is striking that the duration of the boundary syllable was the longest for NIS speakers, even greater than the final lengthening exhibited by English natives (Wightman et al., 1992). Vowel insertion may have caused longer duration for the NIS group because English loan words ending in a consonant are typically produced with an epenthetic vowel [ɨ] (e.g., *bus* is pronounced as[bʌsɨ]).

As for the mean value of the F0 in the phrase-final foot, the results of the analysis of variance returned a significant effect of group, $F(2,899) = 95.553$, $p < .001$. Tukey's tests ($p < .05$) revealed that the mean value of the fundamental frequency was higher for the NIS group, intermediate for IS, and lower for NE group. The results are summarized in Figure 3(d).

These results suggest that the degree of final-strengthening was the largest for the NIS group, with the IS group intermediate between the two other groups. The final foot in the terminal phrases produced by the NE group showed lower F0 and shorter duration, while the NIS group showed higher F0 and longer duration. Final strengthening appeared to be stronger for the NIS group than for NE or IS groups.



(a) Duration of phrase-final foot (S) (b) Mean F0 of phrase-final foot (Hz)

Figure 4. Mean values with standard errors for two acoustic parameters [(a) Duration of the phrase-final foot; (b) Mean F0 value of the phrase-final foot] by three groups of twenty speakers each (NE, IS, NIS)

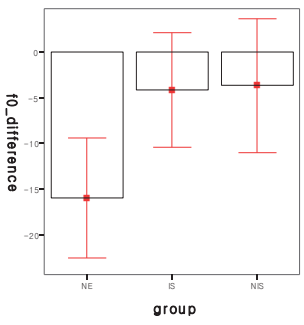
To summarize, it has been observed that a gradual downdrift in the value

of F0 could be found across a phrase (Lieberman and Pierrehumbert, 1984), but the degree is different depending on immersion. NE group had a greater F0 range, faster speech rate, and lower F0 mean and shorter duration of the phrase-final syllable. These characteristics of the measured signals led to the steepest declination tilt. The IS group was in between NE and NIS on these measures.

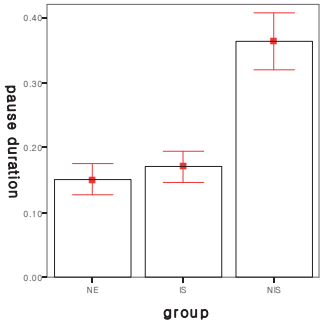
Reset cues

Results of the RM analysis for the inter-phrase cues confirmed a significant effect of group for the F0 difference between the two iPs, $F(2,479) = 3.837$, $p < .05$. Tukey's tests ($p < .05$) revealed that the pitch difference was the largest for the NE group, but lower for the IS and NIS groups. This result indicates that both IS and NIS groups have a smaller F0 difference between the two intermediate phrases. The NE speakers show a greater difference of 16 Hz: the falling F0 of the first phrase and the higher F0 at the onset of the following phrase. Both Korean groups, on the other hand, have smaller differences, around 4 Hz (see Figure 7(a)). This indicates that although the effect of immersion was found to influence L2 intonation in many parameters, no effect of immersion was found for some aspects of intonation. NE speakers produced a difference in fundamental frequency between terminal and non-terminal sentences, while both IS and NIS did not.

Results of the RM ANOVA showed a significant effect of group on the pause duration between the two iPs, $F(2, 599) = 67.545$, $p < .001$. Tukey's tests ($p < .05$) revealed that the pause duration was longer for the NIS group, and shorter for the NE and IS groups (see Figure 7(b)). These results indicate that the pause duration for NISs is the longest (roughly 20 ms longer than the other groups), while members of the IS group had similar or even shorter duration compared to members of the NE group.



(a) F0 difference between two iPs



(b) Pause duration between two iPs

Figure 5. Mean values with standard errors for the non-terminal phrases for two parameters [(a) F0 difference between the two phrases; (b) Pause duration between the two phrases] by three groups of twenty speakers each (NE, IS, NIS)

To summarize, non-terminal phrases for members of the NE group had greater F0 differences and shorter pause durations between phrases than the Korean groups. The declination slope was the steepest for NE group as well. The acoustic realization for IS group was somewhat varied; the duration of the pause between the phrases for the IS was not different from that of the NE group, while F0 between the phrases was not different from that of the NIS group.

6 Relationship between Intonational Production and Intelligibility Test

The production analysis reported that the effect of early immersion influences L2 learners' acquisition of English prosody dependently or independently. One of the remaining questions on the production tests is to what extent their accuracy improvement for the suprasegmental cues could contribute to the intelligible judgment. For the analysis, both rating scores of L2 learners of Korean and their values of intonational features examined in this study were submitted to correlation and regression analyses. Zero-order correlations were computed between the learners' intelligible ratings (n=20) and their intonational measured values.

Table 3. Summary of Correlation Analyses between Intelligible Ratings and Acoustic Measurement

	F0 range	Speech rate	F0 at boundary	Duration at boundary	F0 difference	Pause duration
Intelligible ratings	-.368*	-.637**	-.090	-.256*	-.453**	-.182

**: $p < .001$, *: $p < .05$

The analysis indicates that some of acoustic values measured in this study are significantly correlated with the intelligible ratings.), suggesting that the speech rate is a strong predictor of intelligible decision and also F0 difference is a significant factor in deciding the intelligible resetting pitch contour. In summary, the results suggest that native judgment of L2 speech may reflect the universal features of intelligible judgment; a strong perceptual effect can be existed on the temporal cues such as the speech rate (*should revise*).

7 Discussion

An immersion experience was found to have some influence on the production of L2 intonation in terms of declination tilt and resetting cues. Immersed Korean learners of English (IS) exhibited patterns more similar to those of native English speakers than the non-immersed Korean learners of English (NIS). Namely, they had a steeper declination tilt which includes a wider F0 range, much lower F0 and shorter duration at phrase-final boundaries, a faster speech rate, and a shorter duration of pauses.

Transfer from L1 in forming L2 intonation was proved. In the terminal sentences (i.e., intonation phrases (IPs) with only one intermediate phrase (iP)), NEs had the widest range in fundamental frequency, shortest duration of phrases, and a lowest mean F0 in the phrase-final foot. These characteristics cause the steepest tilt among three groups in both upper-lines and lower-lines. On the contrary, NISs showed the smallest range of F0, longest duration of phrases, and the highest mean value of F0 and longest duration in the phrase-final foot. The declination in both upper-lines and lower-lines thus showed the gentlest slope for the NIS. The IS group members were clearly positioned between the members of the other two groups, having intermediate values for these measures.

The evidence that the early immersion has significant influences on L2 intonation is clear in forming resetting cues. In the non-terminal sentences (i.e., intonation phrases (IPs) with two intermediate phrases (iPs)), NEs exhibited the largest difference of F0 between end of the first phrase and the onset of the second phrase, and the shortest duration of pause between the adjacent phrases. On the contrary, NISs showed a comparatively longer duration of pause and a smaller difference of F0 between the two phrases.

However, the IS group had some confused results: an F0 difference similar to the NIS group and a pause duration similar to the NE group. The IS and NIS groups were not different from each other in the parameter of F0 difference. Both Korean groups imposed a similar tendency in not resetting the F0 between the two intermediate phrases in the non-terminal phrases, while English native speakers produced a large difference in F0 by lowering the F0 in the final portion of the first iP and raising F0 at the initial point of the second iP. It is interesting that the IS group with more than four years of immersion as childhood failed to reset the F0 between the two phrases, even though the duration of the boundary foot for the IS group showed the same patterning as the NE group.

A similar case was found in the declination tilt represented in the terminal sentences. In the declination tilt of the intonation phrase, even though the IS group had a pattern more similar to the NE for the upper-line, the lower-line is clearly more similar to the NIS group. This means that the lower-line that connects the lowest point of fundamental frequency in the initial section to that in the final segment was not affected very much by immersion in an

English-language setting. The immersed learners acquired the intonational pattern of English in terms of final lowering associated with a sense of fading off, or finalizing the terminal sentences, but not in the sense of resetting F0 in the non-terminal phrases.

Failure to reset the F0 may stem from L1 interference. The intermediate phrase in English (the first iP in the non-terminal stimuli in this paper) is marked by a phrase accent, either a high or a low tone associated with the final stressed syllable, which affects the F0 trajectory at the end of the iP. However, the accentual phrase in Korean does not have any phrase accents associated with specific syllables. Rather it has tonal patterns associated with the entire phrase (see discussion in the Introduction). The difference between the languages may make it less likely for Koreans to learn to associate phrase accents with the final stressed syllables of English, especially in cases where the phrase is in a non-terminal position. The F0 difference, along with the duration of the pause, is a decisive mark of finality or non-finality. The Immersed Korean group's failure to reset F0 between intermediate phrases suggests that L1 interference plays a larger role in more local, language-specific linguistic patterns than in global patterns such as F0 declination, F0 range, and speech rate.

Thus, immersion of several years duration does not guarantee a native-like production of intonation. While some aspects were native-like, others were not. More specifically, several years of immersion during childhood appears to improve speech rate, phrase final lengthening, pause duration, and global F0 patterns such as declination tilt and F0 range. On the other hand, more local F0 patterns such as the lower-line of the F0 contour and F0 resetting between phrases were found to be less native-like.

That is, even though immersion was found to have strong, positive effect on the acquisition of second language intonation, certain parameters were still non-native like, viz. the difficulty in controlling the F0 in phrase-final syllable and the comparatively weak resetting of F0 at the adjacent phrases. These differences may cause confusion for listeners in that clear boundary cues may be absent. The listener may not know whether the sentence has ended and another one has begun. Further work assessing the relative intelligibility of speech produced by immersed and non-immersed groups is needed to explore this question.

8 Conclusion

In sum, the immersed group of English learners was found to have more native-like intonation than a non-immersed group of English learners who had similar lengths of English instruction and similar scores on written English proficiency tests. From these result we can infer a facilitative effect of immersion on the production of English intonation in a second language: a steeper declination through wider F0 range and a faster speech rate. However,

some F0-related signals in reset tend to be hard to change in spite of immersion in English in childhood: smaller F0 difference between phrases. The immersed group still holds some production characteristics of intonation which most likely stem from the first language, even though they had immersed English in an English-speaking country for a significant period during childhood. Future research is needed to determine whether these characteristic contribute to diminished intelligibility or to the detection of a foreign intonation.

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Appendix

Experimental sentences

1. The dogs should have eaten the hotdog.
2. The driver took the cab to the town.
3. The player sent the mail to Susan.
4. I can't remember the scene vividly.
5. The people built the beautiful bridge.
6. I have friends who are just like me.
7. Miss Janet drank a cup of coffee.
8. They suspect that the suspect killed Ted.
9. I closed the door and waited for the bus.
10. Jenny walked home from school in the rain.
11. Thirteen years later, Mary met him at the same place.
12. Raise your right hand, if the teacher calls your name.
13. With a light hammer, the carpenter hit the nail.
14. All of a sudden, the man rushed to the market.
15. We went to London, Paris, Cairo, and Boston.
16. The wind and the sun argued one day over which one was the stronger. Spotting a man traveling on the road, they sported a challenge to see which one could remove the coat from the man's back the quickest. The wind began. He blew strong gusts of air, so strong that the man could barely walk against them. But the man clutched his coat tight against him. The wind blew harder and longer, and the harder the wind blew, the tighter the man held his coat against him. The wind blew until he was exhausted, but he could not remove the coat from the man's back. It was now the sun's turn. He gently sent his beams upon the traveler. The sun did very little, but quietly shone upon his head and back until the man became so warm that he took off his coat and headed for the nearest shade tree.